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Figure 1. In hot, wet summer months, annual vinca (*Catharanthus roseus*) often falls victim to *Phytophthora nicotianae*.

PLANT PATHOLOGY IN THE LANDSCAPE SERIES

Phytophthora Diseases in Ornamentals

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Botany and Plant Pathology

Phytophthora species are destructive plant pathogens that resemble 'true fungi' and are commonly referred to as 'water molds.' In Indiana, the most common species of *Phytophthora* found in the landscape include *P. cactorum*, *P. citricola/plurivora*, and *P. nicotianae* (formerly called *P. parasitica*) (Fig. 1), although many other species have been reported. While some of these pathogens find their way to the landscape from infected plants purchased at nurseries and greenhouses, endemic *Phytophthora* spp. also infect landscape plants.

Phytophthora pathogens infect many different hosts including bedding plants, perennials, shrubs and trees. Unlike most plant pathogens, some species of *Phytophthora* have very broad host ranges. In fact, two invasive species, *P. cinnamomi and P. ramorum*, are documented to have several hundred woody plant hosts each; *P. nicotianae* has been reported to infect numerous annuals, perennials and woody ornamentals.

Table 1: Phytophthora feeding preferences. (Please note these are just guidelines, and Phytophthoras do not read.)

	P. cactorum	*P. cambivora*	*P. cinnamomi*	*P. citrophthora*	*P. cryptogea*	*P. drechsleri*	*P. citricola*	*P. nicotianae*	*P. ramorum*	*P. syringae*
Annuals					X	X		X		
Perennials	X				X	X		X	X	
Broadleaf woody ornamentals (angiosperms)	X	X	X	X	X	X	X	X	X	X
Conifers (gymnosperms)	X	X	X		X	X	X	X?	X	

National Plant Diagnostic Network, 2020, used by permission; Erwin, D. C., and Ribeiro, O. K. 1996. Phytophthora Diseases Worldwide. American Phytopathological Society, St. Paul, MN.

Table 2: Landscape plants that have been reported as susceptible or resistant under light to moderate disease pressure in the Midwest. Many plants listed here as resistant are not common in the landscape and are less likely to have been exposed to multiple *Phytophthora* spp. and may be more susceptible than currently believed. It is important to understand that disease resistance may cover a range of reactions from tolerant to immune and a plant that is resistant to one isolate or Phytophthora species may be susceptible to another. Also note that many Midwest annuals are perennial in warmer climates.

Type	Susceptible Plants to Avoid		Resistant Plant Alternatives	
	Common Name	***Latin Name***	**Common Name**	***Latin Name***
Bedding Plants	Snapdragon	*Antirrhinum* spp.	Whiteweed; Flossflower	*Ageratum* spp.
	Begonia	*Begonia* spp.	Angelonia	*Angelonia angustifolia*
	Calendula	*Calendula* spp.	Ornamental Cabbage	*Brassica* spp.
	Million Bells	*Calibrachoa* spp.	Sweet Potato Vine	*Ipomoea batatas*
	Annual Vinca	*Catharanthus roseus*	Morning Glory	*Ipomoea* spp.
	Sweet William	*Dianthus barbatus*	Lantana	*Lantana* spp.
	Gerbera Daisy	*Gerbera* spp.	Alyssum	*Lobularia maritima*
	Dusty Miller	*Jacobaea maritima*	Geranium	*Pelargonium x hortorum*
	Flowering Tobacco	*Nicotiana* spp.	Moss-rose	*Portulaca* spp.
	Daisybush/African Daisy	*Osteospermum* spp.	Marigold	*Tagetes* spp.
	Petunia	*Petunia* spp.	Tree Marigold	*Tithonia diversifolia*
	Phlox	*Phlox* spp.	Mexican sunflower	*Tithonia rotundifolia*
	Verbena	*Verbena* spp.	Purpletop Vervain	*Verbena bonariensis*
	Pansy	*Viola x wittrockiana*		
Perennials			Bluestar	*Amsonia spp.*
			Aster	*Aster* spp.
	Delphinium	*Delphinium* spp.	Canna Lily	*Canna* spp.
	Epimedium	*Epimedium* spp.	Ornamental Sedges	*Carex* spp.
	Euphorbia	*Euphorbia* spp.	Dahlia	*Dahlia* spp.
	Hellebore	*Helleborus* spp.	Purple Coneflower	*Echinacea purpurea*
	Coral bells	*Heuchera* spp.	Blanketflower	*Gaillardia* spp.
	Hosta	*Hosta* spp.	Gazania	*Gazania* spp.
	Lavender	*Lavendula* spp.	Hardy Geranium	*Geranium* spp.
	Oregano	*Origanum vulgare*	Candytuft	*Iberis sempervirens*
	Russian-Sage	*Perovskia* spp.	Lychnis	*Lychnis* spp.
	Jacob's Ladder	*Polemonium* spp.	Mints	*Mentha* spp.
	Sage/Salvia	*Salvia* spp.	Daffodil	*Narcissus* spp.
			Pachysandra	*Pachysandra* spp.
			Black-eyed Susan	*Rudbeckia hirta*
			Tulip	*Tulipa* spp.
Shrubs	Boxwood	*Buxus* spp.	Abelia	*Abelia x grandiflora*
	Holly	*Ilex* spp.	Sweetshrub, Spicebush	*Calycanthus spp.*
	Juniper	*Juniperus* spp.	Summersweet	*Clethra alnifolia*
	Japanese andromeda	*Pieris japonica*	Winterberry	*Ilex verticillata*
	Potentilla	*Potentilla* spp.	Yaupon	*Ilex vomitoria*
	Azalea/Rhododendron	*Rhododendron* spp.	Currants, Gooseberry	*Ribes* spp.
	Lilac	*Syringa* spp.	Roses	*Rosa* spp.
	Yew	*Taxus* spp.	Willow	*Salix* spp.
	Viburnum	*Viburnum* spp.		
Trees	Fir	*Abies* spp.	River Birch	*Betula nigra*
	Maple	*Acer* spp.	Ginkgo	*Ginkgo biloba*
	False-cypress	*Chamaecyparis* spp.	Thornless Honeylocust	*Gleditsia triacanthos*
	Beech	*Fagus* spp.	Sweetgum	*Liquidambar styraciflua*
	Walnut	*Juglans* spp.	Magnolia	*Magnolia* spp.
	Crabapple	*Malus* spp.	Dawn Redwood	*Metasequoia glyptostroboides*
	Pine	*Pinus* spp.	Black Gum	*Nyssa sylvatica*
	Douglas-fir	*Pseudotsuga menziesii*	Spruce	*Picea* spp.
	Oak—Red oak family	*Quercus* spp.	Willow	*Salix* spp.
	Arborvitae (white-cedar)	*Thuja* spp.	Baldcypress	*Taxodium distichum*

What's in a name?

Before the year 2000, 55 species in the genus *Phytophthora* were identified. That number has since increased to more than 250 and continues to grow as new technologies are used to characterize, identify, and distinguish between species. However, ambiguities remain, along with provisional species and hybrid species (Martin et al. 2012). In science, we often think having a name for something is the same as understanding it. For Phytophthoras, this is only the beginning and often requires multiple steps and considerable time for a conclusive identification to be made.

Figure 2. An overly wet spring resulted in Phytophthora shoot blight.
Photo by Eric Biddinger, INDNR.

Symptoms and Signs

Phytophthora spp. are capable of causing shoot blights, crown rots and root rots. Foliar or shoot infections (Fig.2) begin on young, tender leaves and can move down the plant shoot. Shoot dieback symptoms begin with wilting and necrotic lesions on the young leaves that later become water soaked, then brown and brittle. Under wet conditions, the pathogen continues to infect, causing lesions to spread wherever *Phytophthora* feeds on the host plant.

Crown rot occurs when pathogens infect at the root-shoot interface, or as root rots expand to the stem of the plant. This often results in the girdling of the stems and subsequent death of the plant (Fig. 3). Root infection results in scorch or yellowing that may be mistaken for drought or nutrient deficiency (Fig. 4). As the disease progresses below

Figure 3a and b. *Phytophthora sp.* can cause crown rot of trees, shrubs, annuals and perennials., shown here on beech (left) and Russian sage (right).

Figure 4. Phytophthora root infection (shown here on annual vinca) can mimic drought or nutrient deficiency symptoms, resulting in overwatering and overfertilization, making the root rot worse.

Figure 5. Root rot infection by *P. cinnamomi* on rhododendron causes root rot and wilting.

ground, above ground wilting may be present with a blighted appearance on shoots and leaves (Fig. 5). Infected roots often discolor as they rot, and the above ground portion of the plant may be stunted or appear blighted (Fig. 6). Infected plants, especially young plants, can eventually be killed by *Phytophthora* spp. if not managed properly. Severe root rot can result in young plants being easily dislodged from the surrounding soil. Young plants are more susceptible to infection than older plants. Long-lived trees and shrubs, like beech, may eventually succumb to Phytophthora trunk canker and root rot after ~70 years of age, and even earlier if trees have underlying predisposing conditions (Figs. 3a & 7). Phytophthora inoculum from root infections can be splashed up on the plant to infect shoots; and infected shoots may shed spores that fall to the soil to infect the roots of additional plants.

Figure 6. Root exam reveals differences between healthy (right) and infected roots (left).

Figure 7. Older European beech often succumb to *P. citricola* in the Midwest landscape.
(Photo by PPDL)

There are generally no signs of the Phytophthora pathogen visible to the naked eye, however the pathogen's reproductive structures, sporangia and oospores, can be seen under a microscope (Fig. 8 & 9). The sporangia are typically lemon-shaped and the large oospores are thick-walled and round (Fig. 10).

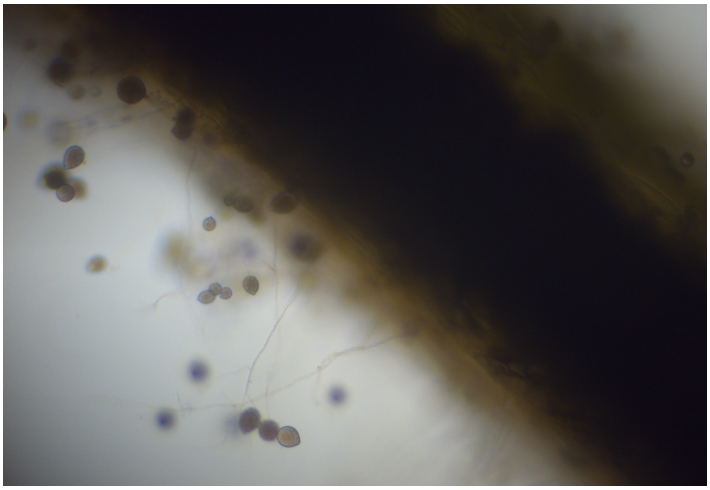


Figure 8. Dissecting scope view of Phytophthora sporulation on infected tissue. (Photo by PPDL)

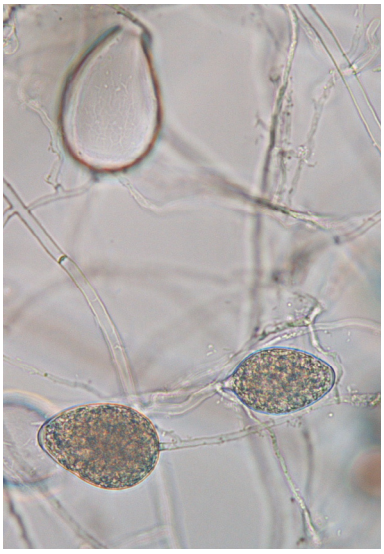


Figure 9. Zoosporangia of Phytophthora. The top sporangium has released all its spores, while the bottom two sporangia are still 'fully loaded.'

Disease Cycle

Phytophthora spp. commonly overwinter as oospores (Fig. 10), thick walled sexual spores, or as chlamydospores, thick cells that act as asexual spores. Both can be found in plant debris. Chlamydospores germinate and form hyphae, that must be near a host plant for infection to occur. Oospores also germinate to do the same thing in drier conditions, but when free water is available, produce a reproductive structure called a zoosporangium from which the motile zoospores are produced (Fig. 9). The zoospores swim and are splashed by water from the soil and leaf litter on to the plant leaves, where they encyst, then infect and invade a susceptible host. The disease cycle is repeated as oospores (Fig. 10) are produced from sexual combination and once again the *Phytophthora* overwinters in fallen leaves and plant debris.

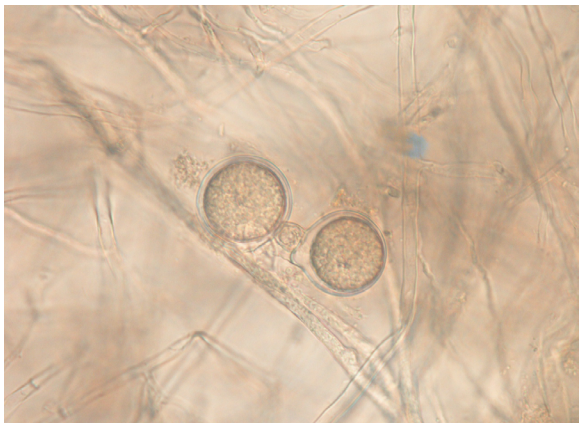
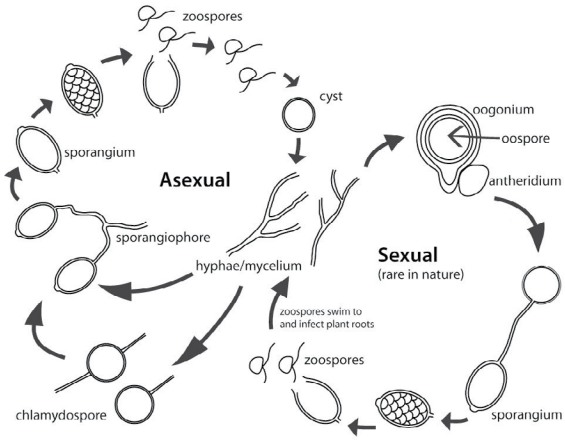


Figure 10. Thick walled oospores of *P. citricola*.



Phytophthora life cycle

Management

Phytophthora spp. are difficult pathogens to manage, especially since multiple species of *Phytophthora* can cause problems and they don't all respond to the environment or fungicides in the same way. Prevention and exclusion are the best options to avoid these diseases altogether. Once the disease is established, the most feasible option is to remove the infected plant parts, or even the entire affected plant. Fungicides can be used to protect plants from infection, not as therapeutic remedies, and must be applied regularly (every 7-28 days, depending upon the label) in order to maintain efficacy.

Prevention

Infection is commonly worse on heavy clay soils, alkaline soils, or soils that are poorly drained due to compaction, bedrock or high water table. Avoid planting highly susceptible varieties (Table 2) in these locations.

Figure 11. Demonstration of Vinca 'Cora' for *Phytophthora nicotianae* resistance. Photo courtesy of Syngenta Flowers.

Newly developed resistant varieties of some plants are available, along with older cultivars that have withstood the test of time. There are a few cultivars of rhododendron, such as 'Roseum Elegans', 'Scintillation', and 'PJM', that have shown some degree of tolerance to the disease. Annual vinca 'Cora' are resistant to *P. nicotianae*, but can be infected by other species of *Phytophthora* (Fig. 11). Current work is underway to evaluate plants for resistance to many different species of *Phytophthora*.

Within the nursery trade, several plants seem to suffer tremendous problems from Phytophthora diseases. These plants, termed the 'filthy five', include Andromeda (*Pieris* spp.), Azalea/Rhododendron (*Rhododendron* spp.); Camellia (*Camellia* spp.), mountain-laurel (*Kalmia latifolia*), and Viburnum (*Viburnum* spp.). Avoid those varieties that have been identified as uniquely susceptible; including Rhododendron cultivars 'Chionoides White', 'Catawbiense Album' and 'Nova Zembla.'

Be sure to purchase plants that are zone hardy for your site, and provide the appropriate light and water necessary for them to thrive. Stressed plants are more susceptible to *Phytophthora* spp. and other opportunistic pathogens. Do not plant species known to be susceptible to Phytophthora diseases in locations where plants have been affected by these diseases in the past, and do not place susceptible annuals in the same location for consecutive years.

Figure 12. Maintaining an area to quarantine and observe incoming plant material protects greenhouses, nurseries and the landscape.

Other important Phytophthora disease prevention techniques:

- Use low nitrogen fertilizers, and avoid ammoniacal sources of nitrogen.
- Irrigate earlier in the day to allow time for the shoot portion of the plant to dry off.
- Avoid irrigation practices that splash water and/or drench the leaves.
- Use mulch around plants to prevent splash of pathogens from soil to plant.
- Grow plants in well-drained soil and do not allow standing water near plants.
- Plant in raised beds if poor drainage is an issue.
- In the greenhouse, grow plants on benches, as far above the ground/soil as feasible, using a well-drained medium appropriate to plant type and size.
- Keep pH on the acidic side to promote growth of Ericaceous plants and discourage *Phytophthora* spp..

Exclusion

It is important to try to exclude *Phytophthora* spp. from the growing area as much as possible. For the landscape, make sure to purchase healthy specimens with no appearance of infection. Incorporate a quarantine or holding area to evaluate incoming plants for signs of infection and prevent the introduction or spread of pests or pathogens into the nursery (Fig. 12). For production, purchase pathogen-free propagative material. Clean and disinfest tools regularly, and avoid bringing outside soil/mud into the nursery or greenhouse. In nurseries with a recirculating water source it will be important to include a method to disinfest the water since Phytophthora spp. are known to survive in ponds.

Eradication

Sanitary cultural practices are the key to Phytophthora disease management. Remove and destroy any infected plant parts, including any leaf and twig litter on the ground, and properly sanitize the pruning tools. In the landscape and nursery, removal of the infected portion of the plant might prove to be a reasonable control measure for shoot blights, but if the infection is severe enough, removal and destruction of the entire plant is advised. Do not replant with the same species or any other species susceptible to *Phytophthora*.

Keep susceptible species in blocks to ease monitoring of disease. Highly susceptible species, like azalea, camellia, kalmia, pieris, and rhododendron (the 'filthy five') often serve as reservoirs for many *Phytophthora* species, including the exotic invasives, *P. ramorum* and *P. cinnamomi*. In the greenhouse, annual vinca, petunia, and calibrachoa are often hosts of *Phytophthora* species. In the greenhouse or nursery, remove and destroy the entire symptomatic plant and plants immediately adjacent to the symptomatic plant, rather than just removing visibly infected parts of the plant.

Pesticides

Fungicides can be used to protect plants against Phytophthora infection (Table 3.), but applicators need to be aware that multiple applications will be necessary over the growing season, or the life of the plant, to provide continuous protection. Keep in mind that fungicide resistance has been identified in isolates of several *Phytophthora* species, including greenhouse isolates found infecting bedding plants. Apply systemic fungicides, such as fosetyl-Al (Aliette) or phosphorous acid (Rampart, etc.) in rotation with mefenoxam (Subdue Maxx), dimethomorph (Stature DM), oxathiapiprolin (Segovis) or mandipropamid (e.g. Micora). Use these systemic fungicides in rotation, according to label directions, and only as needed, in order to minimize the risk of fungicide resistant isolates from evolving and becoming established in your planting. Always read and follow the fungicide label instructions and rotate fungicide type frequently when using systemic materials. For more information on rotations see https://www.extension.purdue.edu/extmedia/BP/BP-71-W.pdf .

Table 3. Fungicides for Phytophthora Management

Fungicides (active ingredients)	FRAC Code	Sites*	REI	Comments
Adorn (fluopicolide)	43	G, L, N S	12 h	
Aliette WDG (fosetyl Al)	33	G, N	12 h	Broad spectrum against a number of oomycetes.
Alude, Magellan, Vital, etc. (phosphorus acid salts)	33	G, N	4 h	Broad spectrum against a number of oomycetes.
Banol, Proplant (propamocarb)	28	G, N	24 h	
Banrot (etridiazole+thiophanate methyl)	14 + 1	G	12 h	Broad spectrum against a number of pathogens.
Broadform (trifloxystrobin+fluopyram)	7+11	G, I, L, N, S	12 h	**Not labeled for Pythium; Broad spectrum against a number of pathogens.**
Disarm O (fluxostrobin)	11	G, I, N, S	12 h	**Not labeled for Pythium.**
Dithane 75 Rainshield (mancozeb)	M3	G, N	24 h	Contact action/protectant fungicide
Empress (pyraclostrobin)	11	G, I, L, N, S	12 h	Broad spectrum against a number of pathogens.
Fenstop (fenamidone)	11	G	12 h	Broad spectrum against a number of pathogens.
Heritage (azoxystrobin)	11	G, L, N, S	4 h	Broad spectrum against a number of pathogens.
Micora (mandipropamid)	40	G, N, S	4 h	**Not labeled for Pythium.**
Mural (azoxystrobin+benzovindiflupyr)	7 + 11	G, N, S, L	12 h	**Not labeled for Pythium;** Broad spectrum against a number of pathogens.
Orkestra (fluxapyroxad + pyraclostrobin)	7 + 11	G, I, L, N, S	12 h	Broad spectrum against a number of pathogens.
Orvego (ametoctradin+dimethomorph)	40+45	G, I ,N ,S	12 h	**Not labeled for Pythium.**
Pageant Intrinsic (pyraclostrobin+boscalid)	11+7	G, I, L, N, S	12 h	Broad spectrum against a number of pathogens.
Segovis (oxathiapiprolin)	U15	G, N S	4 h	**Not labeled for Pythium.**
Segway (cyazofamid)	21	G, L, N	12 h	Limited systemic activity
Stature DM (dimethomorph)	40	G, N, S	12 h	**Not labeled for Pythium.**
Subdue Maxx (mefenoxam)	4	G, L, N, S	0 h	Resistance identified in some cases.
Terrazole, Truban (etridiazole)	14	G, N	12 h	Contact action/protectant fungicide

*G=Greenhouse; I=Interiorscape; L=Landscape; N=Nursery; S=Shadehouse

Setting up your rotation: A number of fungicides are labeled for the control of *Phytophthora* spp. (Table 4). These should be used when needed and always in rotation. Some fungicides, like Adorn, require that the user tank mix it with another fungicide that is effective against *Phytophthora* spp. Fungicides are effective between 10 to 28 days, depending upon label description and environmental conditions. Below is an example fungicide rotation for controlling Phytophthora aerial blight. Under drier periods of low disease pressure, the pest manager may elect to extend the period between sprays to 14 days; under higher disease pressures (frequent or heavy rains), the pest manager may need to re-apply the fungicide. As always, read and follow the label restrictions regarding fungicide use.

Table 4. An example rotation for use in ornamental production to protect *Phytophthora* susceptible plants like azalea (*Rhododendron* spp.), rhododendron (*Rhododendron* spp.), andromeda (*Pieris* spp.), hellebore (*Helleborus* spp.), sage (*Salvia* spp.), annual vinca (*Catharanthus roseus*), petunias (*Petunia* x *hybrida*). and calibrichoas (*Calibrichoa* hybrids).

Day 1	Day 10	Day 20	Day 30	Day 40	Day 50	Day 60
Subdue Maxx OR Segovis	Orvego or Stature DM or Segway or Micora	Aliette or Rampart	Adorn + Aliette	Orvego or Stature DM or Segway or Micora	Aliette or Rampart	Adorn + Aliette

Phythophthora pathogens can be managed in the greenhouse, nursery and landscape. Identifying which *Phytophthora* species is causing the problem is the first step and an important one to limit the spread of potentially exotic, invasive species. After diagnosis, the use of an integrated pest management program, coupled with rigorous sanitation and the judicious use of fungicides, can successfully manage the spread and loss caused by these pathogens.

All photos by Janna Beckerman unless otherwise mentioned.

References

Abad, G., Burgess, T., Bienapfl, J.C., Redford, A.J., Coffey, M., Knight, L.., 2019. IDphy: molecular and morphological identification of *Phytophthora* based on the types. http://idtools.org/id/phytophthora/about.php

Martin, F.N., Abad, G., Balci, Y., Ivors, K., 2012. Identification and detection of *Phytophthora*: reviewing our progress, identifying our needs. Plant Dis. 96, 1080–1103.

Erwin, D. C., and Ribeiro, O. K. 1996. Phytophthora Diseases Worldwide. American Phytopathological Society, St. Paul, MN.

Creswell, T. Ivors, K., and Munster, M. Suggested Plant Species for Sites with a History of Phytophthora Root or Crown Rot. Online at: https://plantpathology.ces.ncsu.edu/wp-content/uploads/2013/05/AG-747_Crown-Rot.pdf?fwd=no

Leonberger, A.J., Speers, C., Ruhl, G., Creswell, T., and Beckerman, J.L. 2013. A survey of *Phytophtohora* spp. in Midwest nurseries, greenhouses, and landscapes. Plant Dis. 97:635-640.

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